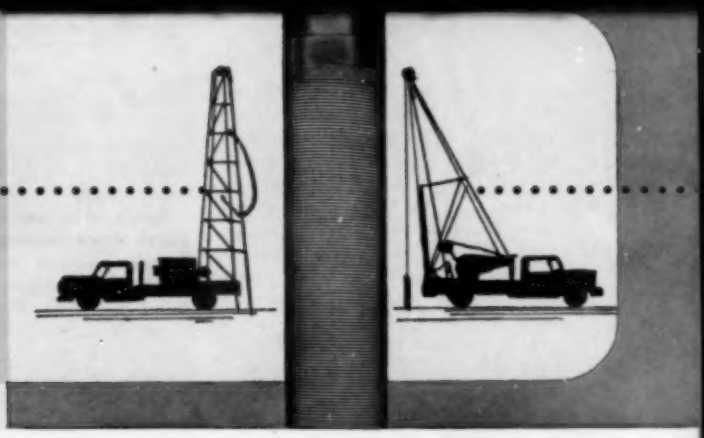
The Johnson National DRILLERS JOURNAL



Vol. 27, No. 5 The Johnson National Drillers' Journal September-October, 1955

Hydraulic Principles Involved

Factors Affecting Well Yield

• *Part One of this article in the July-August issue discussed some fundamental hydraulic principles and outlined the factors that affect well yield. These factors are reviewed in more detail in this second part.*

The individual factors that affect the yield of screened wells fall into three groupings. One group of these factors includes the natural characteristics of the water-bearing sand; a second group includes the elements of well design such as well diameter, screen length, screen openings and type of screen; and the third group includes the methods used in construction and developing the well.

The drilling contractor can do nothing to change the natural characteristics of the water-bearing formation. However, with a full understanding of how each peculiarity of the formation affects well yield, he can select the location for a well where the aquifer conditions are most favorable. Also, by applying his knowledge of the influence of the aquifer characteristics, the driller or engineer can design a well to best fit the hydrologic and geologic conditions that preliminary test drilling may reveal. This means that he does control the second group of yield factors — the elements of well design. The driller also controls the third group that embraces methods of drilling and developing the well.

Grading of Formation

Almost everyone knows that formations made up entirely of coarse material like gravel give relatively high yields. Because of the larger particle sizes in such a formation, the pores or voids are larger. The large pores offer less resistance to flow than the smaller pores in finer sands so more water will flow through each square foot of the coarser material with a given amount of drawdown.

Comparative laboratory tests of a fine sand and a coarse sand show clearly the effect of particle size, other things being equal. As an example, a coarse sand of 0.018-inch average size was tested and found to have a permeability of 1,500 gallons per day per square foot. A fine sand of 0.009-inch average size had a permeability of only 45 gallons per day per square foot. The porosity of both samples was the same — each contained 35 per cent voids. Even though the total volume of voids was the same, the smaller pores in the finer sand caused a great increase in resistance to flow, that is, decrease in permeability.

It is almost impossible to discuss the effect of particle size on permeability without also speaking about uniformity of grading, because the degree of uniformity varies with the amounts of fine and coarse in a mixture of sizes. When a sand consists of particles all about the same size, the material is said to be uniformly graded. Mixtures with a large range in size from fine to coarse are non-uniformly graded.

Porosity Is a Factor

A uniformly-graded sand has a higher porosity than a less uniform sand-gravel mixture. In the mixture of fine and coarse the porosity is reduced because the finer sand fills the openings between the gravel particles, the result being a more compact arrangement and less voids. The permeability of the denser mixture is usually lower than that of the sand fraction with the gravel taken out. Here the more uniform grading of the sand fraction gives it a higher permeability in spite of its smaller particle size.

A recent investigation* of the permeability of sand and sand-gravel mixtures has shown that when the gravel content is about 20 per cent (and in some cases up to 50 per cent) the permeability of the mixture is much less than the permeability of the sand fraction alone. The sand fraction in these tests was considered as the material finer than the 4-mesh (0.185-inch) sieve; the gravel fraction was all the material coarser than the 4-mesh sieve.

Based on this series of tests, the effects of various amounts of gravel in a sand-gravel mixture can be described in the following general terms. Up to about 20 per cent gravel, the gravel particles are dispersed in the sand por-

*See ASTM Special Technical Publication No. 163, "Symposium on Permeability of Soils." American Society for Testing Materials, Philadelphia, Pa.

Please Note

EDWARD E. JOHNSON, Inc., has moved to new and larger quarters. The new address is 315 North Pierce Street, St. Paul 4, Minnesota, and our telephone number will remain MIdway 6-2555. Please make a note of this, so that we may continue to serve you efficiently.

tion — they do not interfere with one another to any extent — but they cause the mixture to become more broadly graded and they reduce the permeability considerably below that of the sand portion alone. As the amount of gravel increases above 20 per cent the grading is made still less uniform. There is variable interference among the coarser particles and the permeability may increase or decrease as compared to values for gravel contents below 20 per cent. This variable condition can be expected up to 65 per cent gravel in the mixture. For gravel contents over 65 per cent, there is major interference of the coarser particles, the voids are not entirely filled with sand, the density decreases, and the permeability rapidly increases.

From the discussion on the effect of grading, we see that the void characteristics of a sand that affect its permeability include not only the total percentage of porosity but also related things such as the size, distribution and continuity of the voids. Silt and clay or other cementing materials may partially or completely fill the voids in a sand and make it almost impervious. Even when present in small proportions, these cohesive materials may cut off many of the pores, even if they do not actually fill the pores, so that the passages within the sand body are left only partly interconnected. Small amounts of silt and clay may thus greatly reduce permeability.

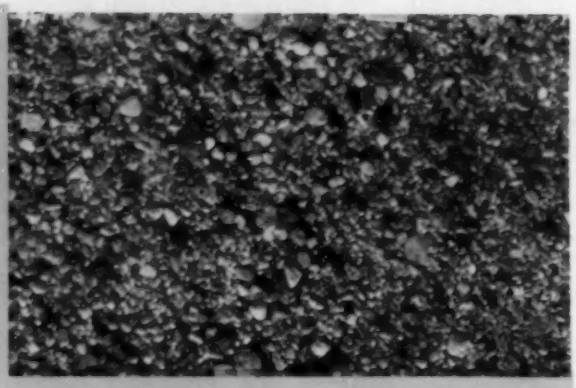
Stratified Formations

The thickness of an aquifer and the degree to which it is stratified are both important in their effects on the yield of wells. The thicker an aquifer is the more water it will conduct to the well. Even though the rate of flow per square foot may be fairly low in a fine sand formation, high capacity wells can be obtained if the formation is of sufficient thickness.

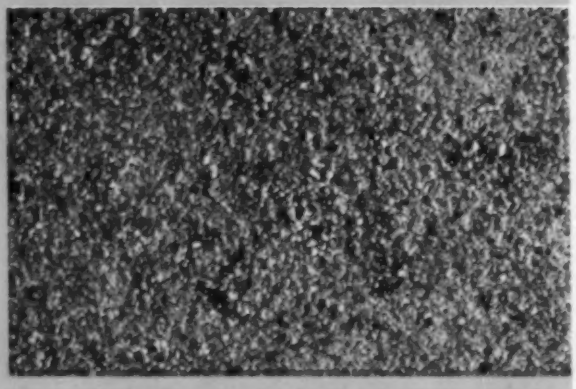
Most aquifers are stratified — that is, they consist of different layers of fine sand, coarse sand and sand-gravel. Some strata are clean, others contain some silt and clay. Sometimes layers of clean sands are separated by streaks of clay only a fraction of an inch thick. All this stratification affects the ability of the aquifer to transmit water to a well.

For instance, clay layers even a fourth of an inch thick may cut off vertical percolation or downward movement of water from one sand stratum to another. Although the flow of water toward a well is normally considered as horizontal, a study of the drawdown curve will show that some vertical flow is involved also, particularly in the vicinity of the well. Thus, impervious strata that interfere with free vertical flow in the aquifer usually affect well yield adversely. The amount of downward movement of water as it approaches a well depends, of course, upon the length of the screen as compared to the thickness of the aquifer.

Separation of clean sands and gravels into fine and coarse layers in a water-bearing formation probably improves the permeability of the formation over what it might be if all the material were mixed together and deposited as a single material with the same grading throughout. This reasoning is based upon the findings and discussion of the advantages of uniformly-graded sands. The different strata in the aquifer have been formed by a sorting out of coarser material at one time and finer material at another period as the sands and gravels were deposited as glacial outwash, alluvium, or marine beds. Due to this sorting, the material in each stratum is likely to be more uniformly graded than a mixture of the several strata would be. More uniformity in the individual strata gives the whole



Sample of sand-gravel, water-bearing formation appears to be mostly coarse particles.



Two-thirds of the sample is this sand that passes a No. 50 slot (0.050-inch) screen.

One-third of the sample is fine gravel held out by the No. 50 slot screen.

aquifer greater transmitting or yielding capacity.

Well Design Factors

These remarks about how stratification can either limit or improve the yield of a water-bearing sand suggest that a well must be carefully designed to take best advantage of the favorable aspects of aquifer stratification if highest yield is desired. This usually means selecting the proper screen for the well — one that is of the correct length and with slot openings selected to fit the sand of each individual layer.

The screen must be long enough to take in the major portion of the most permeable strata penetrated by the well. The section of the screen exposed to each stratum must have the right size slot openings to permit proper development at each level. This insures that the well will take advantage of the full yielding ability of the whole aquifer.

If an aquifer 20 feet thick consists of eight feet of fine sand on top and 12 feet of coarse sand or gravel below, a well screen 10 or 11 feet long is adequate to obtain practically the full yield of the formation. This assumes that a continuous-slot well screen is used, so that sufficient inlet area is provided, and that the water in the fine-sand portion of the aquifer can percolate freely into the coarser, more permeable layer below in which the screen will be set.

On the other hand, if the 20-foot aquifer consists of 10 feet of coarse sand above and 10 feet of fine sand below, a screen length of 15 or 16 feet will be needed to obtain the highest practicable yield. Again, if the whole 20-foot thickness were a fine sand, the well screen should be at least 16 feet long for best results.

These illustrative examples of screen lengths are for wells in which the static water level stands several feet or more above the top of the water-bearing sand. If the static level is lower, say one or two feet below the top of the sand, the screen must be shorter so that more footage of available drawdown is provided. By available drawdown we mean the distance from the static water level to the top of the screen and we assume that when the well is pumped the water will not be pulled down below the top of the screen.

Well Discharge Formulas

Wells operating in two types of aquifers must be considered in discussing well-discharge formulas. In one type, the water table stands within the body of sand and only a part of the full thickness of the sand is saturated. Wells in this type of aquifer are called non-artesian or water-table wells. In the second type of aquifer, the water-bearing sand is confined between layers of relatively impervious material — shale below and clay above, for example. The full thickness of the sand is saturated and the water is under enough pressure to cause the level to rise above the top of the sand when a well is drilled into it. Such a well is said to be artesian or to operate under artesian conditions. The water-bearing stratum may or may not be under sufficient pressure to cause the well to flow at the ground surface, but is called an artesian aquifer if the water level rises any distance above it.

Well-discharge formulas have been derived by various investigators. The two presented here are based on the assumption that the pumping level and cone of depression become stabilized when the well is pumped at a constant rate, Q. In other words, the pumped well is in equilibrium with the aquifer conditions. The formulas given here apply only to equilibrium conditions.

These formulas also assume that the water-bearing sands are of the same character in all directions, with no stratification. They also assume the aquifers to be of constant thickness and that the wells penetrate to the bottom of the aquifers. Figure 3 shows a section through a well operating under water-table conditions. Figure 4 shows a section of a well in an artesian aquifer.

The formula for the water-table well in Figure 3 is

$$Q = \frac{\pi P (H^2 - h^2)}{2.3 \log \frac{R}{r}}$$

where

Q is the pumping rate, in gpm
P is the permeability of the water-bearing sand, in gpm per square foot
H is the saturated thickness of sand from static water to bottom, in feet
h is the depth of water in the well while pumping, in feet
R is the maximum radius of the cone of depression, in feet
r is the radius of the well, in feet

The formula for the discharge or yield of a well operating under artesian conditions as shown in Figure 4 is

$$Q = \frac{2 \pi m P (H - h)}{2.3 \log \frac{R}{r}}$$

Figure 3. Well in water-table aquifer.

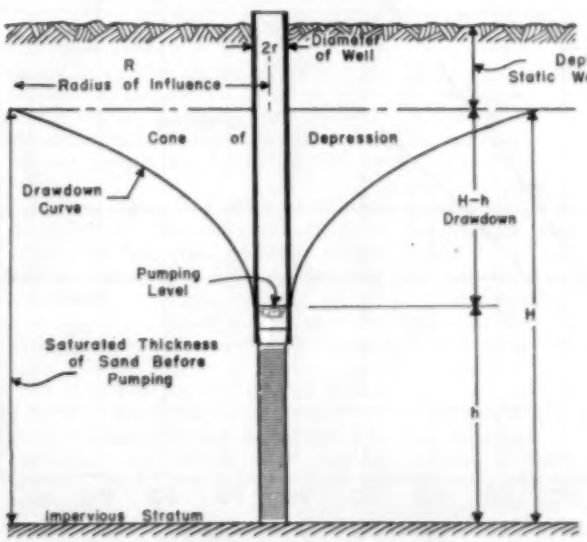
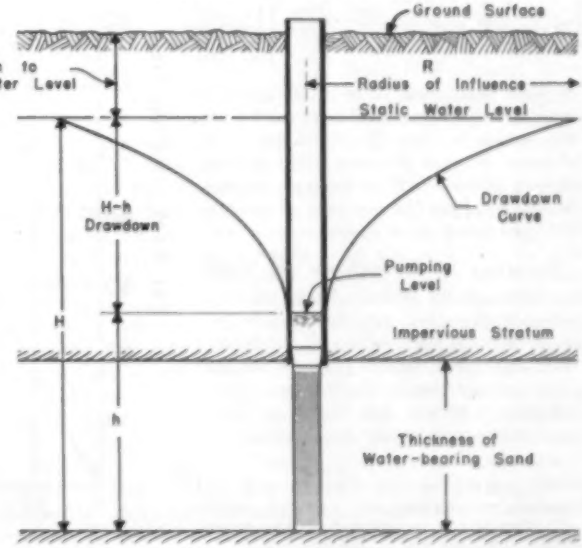


Figure 4. Well in artesian aquifer.



where all the terms have the same meaning as in the first formula except that H is the static head in the aquifer and h is the head in the aquifer at the well while pumping. The thickness of the aquifer, m, in feet also is found in this formula. The expression (H—h) is the drawdown in the well, in feet.

These formulas are not entirely satisfactory for computing the yield of a well in advance. The main reason for this is that we have no reliable way of determining the permeability, P, without drilling and pumping a test well. Even though they may not be used for calculating actual yield, these formulas show the relation of the various factors to the well yield and to each other.

To determine the permeability of an aquifer from data obtained while pumping a test well, the Theis formula based on non-equilibrium conditions must be used. This formula can be applied when the pumping level and the cone of depression have not become stabilized and is much more accurate and useful than the equilibrium formulas. An explanation of the theory and application of the Theis formula is, however, beyond the scope of this article.*

The equilibrium formulas show how the radius or diameter of a well affects the yield. Many persons assume that if you double the diameter of a well you will double its yield. This is far from true. The following table shows the theoretical increase in yield that would result from enlarging the well diameter, all other factors remaining the same.

	Well Diameters					
	6″	12″	18″	24″	36″	48″
	100	111	119	125	135	143
Yield		100	107	112	121	128
			100	105	111	120
Ratios				100	108	110
					100	106

Note that these yield ratios apply to specific capacity as well as to total yield. For example, if a 12-inch well is producing 20 gpm per foot of drawdown, then a 24-inch well in the same location would produce 112 per cent as much or 23 gpm per foot of drawdown.

Relation of Drawdown to Yield

Although the well-discharge formulas already described are theoretically correct, they do not include all the factors that affect well yield. They do not take into account screen length in relation to aquifer thickness nor the head losses due to the well screen resistance or lack of adequate development. When perforated pipe or inferior well screens are used, the water level immediately outside the well may be several feet or more higher than the pumping level inside the well because of high "entrance losses."

Obviously, the change in yield with change in drawdown is different for each individual well. However, some average curves of the drawdown yield relation have been compiled by plotting the measurements taken from a large number of wells operating under varying conditions. The two curves shown in Figure 4 are the result. They serve to show, with fair accuracy, how a well that has been tested at one value of drawdown will operate when pumped at a different drawdown.

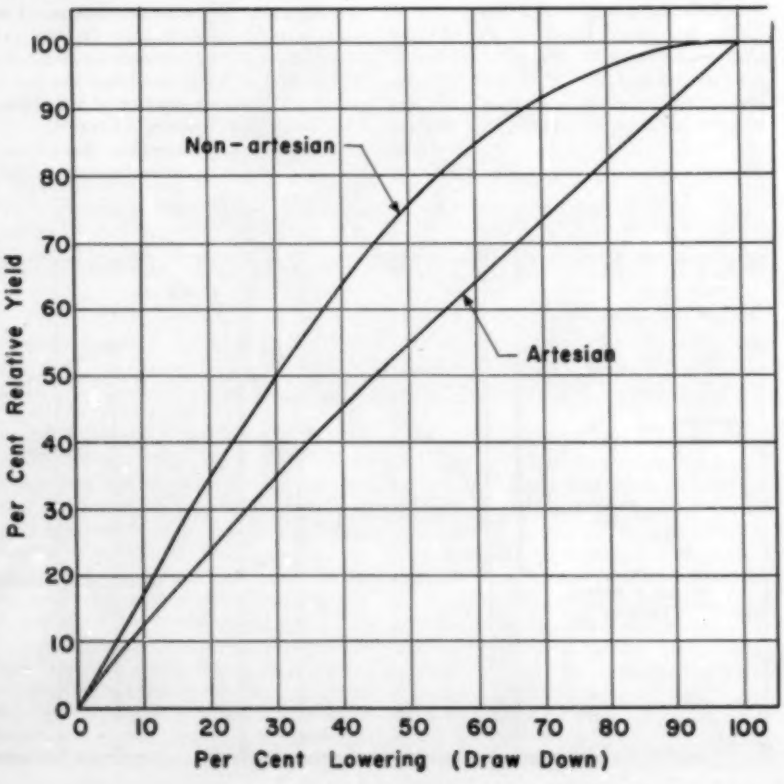
The curves show per cent drawdown against per cent yield. One hundred per cent drawdown, here means pulling the water level down to the bottom of the well; 50 per cent drawdown means pulling the water down half way from static level to the bottom of the well. Maximum, or 100 per cent, yield is the amount that the well will deliver at 100 per cent drawdown. Note that the curves are quite different depending on whether the well operates under "artesian" or "non-artesian" conditions.

The following three examples show how these curves are used to estimate well performance under operating conditions that are different from the test-pumping conditions.

Example 1. Suppose we have a water-table well (non-artesian). The well is 120 feet deep with static level at 20 feet making a water-depth of 100 feet in the well. On test it pumped 100 gpm and the pumping level became stable at 40 feet which is a drawdown of 20 feet. We want to estimate the yield at 40 feet drawdown (pumping level at 60 feet.)

In this case, 100 per cent drawdown would be a drawdown of 100 feet. The 20-foot drawdown during the test is, thus, 20 per cent of the total possible drawdown. Referring to the upper curve of Figure 5, we see that at 20 per cent drawdown the yield is 35 per cent of the maximum that can be obtained; thus 100 gpm is 35 per cent of the maximum yield of the well. A drawdown of 40 feet is 40 per cent of the total possible drawdown, and the upper curve shows that this drawdown should give 64 per cent of the maximum yield. If 100 gpm is 35 per cent relative yield,

Figure 5. Average drawdown-capacity curves for screened wells in non-artesian and artesian aquifers.



*Application of the Theis formula and analysis of pumping test data for specific situations may be requested of the Engineering Department, Edward E. Johnson, Inc.

then 64 per cent relative yield is

$$\frac{35}{64} \times 100 = 183 \text{ gpm}$$

Thus, the well can be expected to yield 183 gpm at 40 feet drawdown.

Example 2. Suppose we have the same well under "artesian" conditions.

From the lower curve of Figure 5, 20 per cent drawdown gives 24 per cent relative yield. Thus 100 gpm, in this case, is 24 per cent of the maximum possible yield. Increasing the drawdown to 40 per cent gives 46 per cent relative yield.

If 100 gpm is 24 per cent relative yield, then 46 per cent relative yield is

$$\frac{24}{46} \times 100 = 191 \text{ gpm}$$

Example 3. Should a non-artesian well be operated with a drawdown greater than 70 per cent of maximum? From the upper curve, Figure 5, we see that for 70 per cent drawdown the relative yield is about 92 per cent. Thus when we have pulled the water down 70 per cent of its original depth we are getting all but eight per cent of the possible yield of the well. In order to get this last eight per cent, we would have to use an additional 30 per cent drawdown. Obviously, the extra pumping cost would be out of proportion to the increase in yield.

Many drillers overlook the relations we have described here. Even though they are approximate, the curves shown will permit good estimates of yield to help avoid being badly fooled by poor guesses on how a well may perform. Their use is most practical in connection with the selection of the correct pump to fit a well's operating characteristics.

Selecting Well Screen

To insure proper functioning and maximum yield of a well in sand and gravel formations, the design of the well screen is all-important. Although some of the details of screen selection have already been discussed, the most important features can be summarized as follows:

1. The well screen must be of adequate length. In most cases, yield increases in proportion to screen length and the depth to which the formation is penetrated.

2. Correct sizes of screen openings must be selected to fit the grading of each different stratum of sand.

3. Maximum open area per square foot of screen surface is essential to reduce inlet velocity and drawdown. The continuous-slot type of screen provides greatest open area for any size slot opening.

(Continued on Page 15)

ISGS 50 Years Old

Anniversary Observed

Natural Resources Building that houses the laboratories and offices of the Illinois State Geological Survey.

The Illinois State Geological Survey celebrated its Fiftieth Anniversary on October 11, 1955. Founded in 1905, the Survey has had a steady development and enjoys world-wide distinction among research institutions and state and provincial geological surveys. Its program of research in the field and laboratory provides information of fundamental, economic and educational value on the geology, geochemistry, geophysics and mineral economics of the natural resources of Illinois.

The full-time staff numbers 48 geologists, 22 chemists and physicists, four chemical, mechanical and petroleum engineers, two mineral economists, a librarian, two editors, 30 technical assistants, and 20 non-technical persons. It has its own quarters in the recently completed Natural Resources Building and accessory units which were built solely for the research and extension work of the Geological and Natural History Surveys at a cost of about $3,500,000. Forty geological laboratories are fully equipped for specialized purposes.

Geological studies relating to the appraisal and development of ground water supplies are an important activity of the Illinois Geological Survey. We salute this outstanding organization for its 50 years of service to the people of Illinois.

Recharge Experiment Successful

By WILLIAM L. BROADHURST AND GORDON W. WILLIS

Recharge or the replenishment of the underground water reservoir is one of the problems under study by the High Plains Underground Water Conservation District. The Water District has two recharge projects, one in Floyd County, five miles east of Petersburg on the Allmon farm and one in Lynn County, four miles west and one and one-half miles south of New Home.

The project in Floyd County is on a lake that lies just south of the Allmon Gin at the old Allmon School. The lake covers an area of about 40 acres, and the drainage area around the lake contains 475 acres. A topographic map of the lake bed was made by the Water District in order to establish a rating curve so that the volume of water in the lake can be determined at any time by measuring the depth of the water.

In October, 1953, a well was drilled near the north edge of the lake to a depth of 377 feet. It was cased from top to bottom with 12-inch gas line casing, perforated with half-inch slots from 130 feet to the bottom. A pump was installed and the well was developed by pumping approximately 1,000 gallons a minute for several days. A pit 30 feet wide, 100 feet long, and 8 feet deep was dug around the well and the dirt was used to build a dam between the pit and the lake. An 18-inch concrete line, equipped with a 15-inch valve on the lake end and a flow meter on the pit end, was installed through the dam. Concrete was poured around the casing in the bottom of the pit and the casing was perforated from the concrete to the top. See Plate 1.

The rain that fell on June 2, 1955, amounted to 2.6 inches on the watershed of the lake and the runoff to the lake

Top of recharge well and pit around well. Pipe for conducting lake water to pit can be seen at the left.

Lake water flowing into pit and recharge well during High Plains recharge experiment.

was 52 acre-feet. The water stood in the lake about 30 hours to allow the heavier particles of silt to settle before the recharge experiment was started.

At 10:30 Saturday morning, June 4, the valve was opened and the water flowed from the lake into the pit surrounding the well and then through perforations in the upper part of the casing into the well.

During the first 30 minutes after the valve was opened, several thousand gallons a minute flowed past the meter from the lake and filled the pit to the same level as the water in the lake. See Plate 2. As soon as the pit filled, water entered the well and flowed out in the sand below at the rate of 1,050 gallons a minute. As was expected, the rate of flow decreased and at 3:30 in the afternoon the flow was 835 gallons a minute. At 10:30 Saturday night, 12 hours after the start, the flow was 630 gallons a minute. At the end of the first 24 hours, the well had taken 964,000 gallons and was taking water at the rate of 540 gallons a minute.

At the end of 48 hours it had taken 1,675,000 gallons and was taking water at the rate of 483 gallons per minute; at the end of 72 hours the quantity that had entered the well was 2,317,500 gallons and the rate was 415 gallons a minute; and after eight days and nights, at 10:30 Sunday morning, the well had taken in 4,200,000 gallons and was still taking water at the rate of about 200 gallons a minute. This quantity of water that is now stored in the sand beneath the ground and available for future pumping is equal to about 13 acre-feet and is sufficient to put four inches of water on 39 acres of land.

Mr. Broadhurst is chief hydrologist of the High Plains Water Conservation District No. 1, Lubbock, Texas. Mr. Willis is district geologist of the High Plains Water Conservation District No. 1, Lubbock, Texas.

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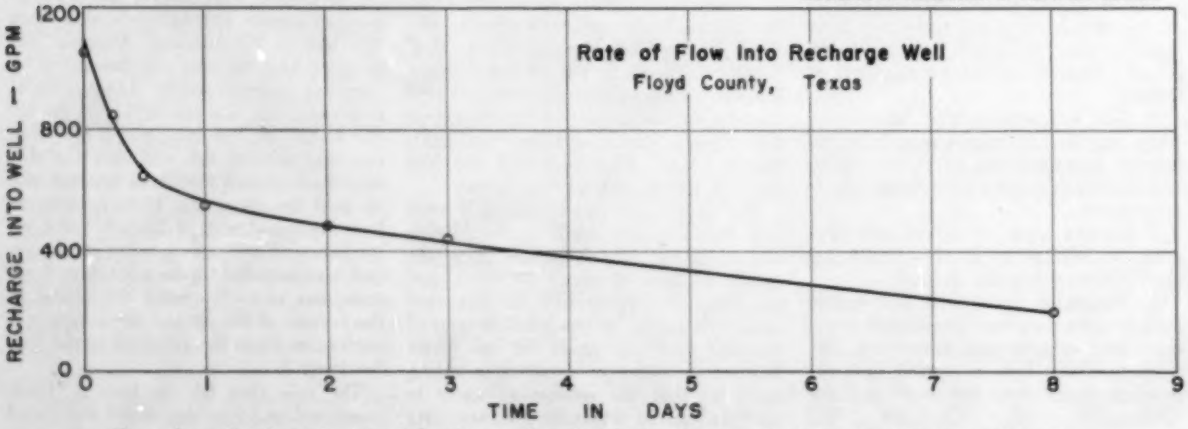


Curve shows the change in rate of flow into aquifer, through the recharge well, during the eight days of operation.

TOM'S COLUMN

I reckon there's some o' you fellows who figure I'm too stiff-necked to admit I make mistakes or that my crews pull off any boners. After all, we drillers like to remember an' talk about th' *good* jobs we've done an' not th' bad ones. That's just natural, because th' good ones make the old bank balance go up, but man-alive, how those bad ones eat it up! Th' sooner we can forget some jobs, th' happier we are.

That goes for all of us. Believe me, in my own business we have our share o' bad ones — and I've made my full quota of mistakes through all these years. Once in awhile it's a good idea to hash over some of these mistakes — just to be sure we've learned something from 'em that will balance out some of th' loss. We can really learn more from our mistakes than we can from our successes, in most cases. So this time I'm goin' to let you in on a couple o' my mistakes this year.

Now, when I say "mistakes," I don't mean bad jobs where you're just a victim of circumstances — not so-called "acts of God" and things out of our control. Those are bound to come up, an' they are a real part of th' cost of well drilling — a *very real* cost which will ruin any driller who doesn't take them into consideration in his prices. What I'm thinking of now, though, is those mistakes that come from carelessness or thoughtlessness; those bad jobs that might not of been bad if we had really used our heads and our experience.

Experience Ignored

Now one that made me feel kind of ashamed of myself wasn't carelessness at all but failure to benefit by all these years of experience which should have taught me that there isn't anything sure and certain in well drilling.

We got a call from a customer who wanted a well added into their water supply field. They had about 10 or 12 acres laid out as a well field. Years ago we had put down a half dozen test wells for them, and put in their first three wells, which were 16-inch natural-developed wells from 105 to 117 feet deep with about 15-foot screens having slots between 60 and 80. They all pumped about th' same — 50 gpm per foot o' drawdown. Just lately — summer of '52 — we put in another 16-inch well an' three test wells for measuring drawdown out away from th' big well. We ran a long pumping test with their engineers taking th' dope an' working out what this water field was good for as a steady supply.

Th' whole thing showed up good. This new 16-inch well gave 'em about th' same as the others, and th' whole field was good for a steady supply of up to 10 million gallons a day. There was enough room to set out th' wells, so they didn't have too much interference with each other.

When their plant engineer called up this summer and asked us to come to their office and go over their plans for another well, pump and pumphouse, we went over with all th' confidence in the world that this was another one of those jobs every well driller loves — nice job at a fair price for first-class people under ideal working conditions in a location we knew frontwards and backwards. What more can any well driller ask for?

When we got over there we found out that th' job was as hot as a pistol. They had gotten a good-sized increase in one of their contracts if they could get going quick. They had everything figured out how they could do it o.k. by converting

(Continued on Page 11)

Promoting Better Wells

Recognizing that the public needs facts and reliable information about ground water resources, water supply and standards for judging competent well drilling performance, the Manufacturers' and Suppliers' Division of the NWWA has formed a committee on public education. This committee will publicize in newspapers, magazines, on radio and television the full story of developing satisfactory running water supplies in rural areas.

The business of well drilling is booming, largely because of the continuing exodus from the city to the country where home owners have to put in their own water supply systems. Everyone is getting into the act. Irresponsible, fly-by-night drillers not far removed from the water witches of old, interested primarily in making a quick profit and moving on to the next job, compete in the same territories with ethical, technically-trained and experienced well drilling contractors who work under contract agreements with the well owner.

Unfortunately, in the haste to buy a lot, build and move into a new grass roots home, many city residents have been less than discriminating in selecting a well driller. Those who have fallen prey to unscrupulous operators have had good reason to regret their snap decisions.

The public education campaign will be built around the dependable well drilling contractor and the service he provides, since a well is the starting point for most water systems. Each unsatisfactory well drilled reflects discredit not only on the offending driller, but on the industry as a whole. Every effort will be made to wean the public away from water witching, old wives tales and fly-by-night operators who lower industry standards. To this end, distinguishing characteristics of the competent and thoroughly qualified well drilling contractor will be emphasized.

The program is aimed additionally at educating both farm and non-farm rural homeowners to the need for wells and pumping equipment of much larger capacity to meet increased water demands of modern appliance-regulated living.

C. D. Leiter of the F. E. Myers and Brothers Company is chairman of the committee. Other members are: Carl Carlberg of Mid-West Well Supply Company; A. A. Dowiend of Sanderson Cyclone Company; R. A. Hindman of Larkin Company; C. J. Stubble of National Supply Company; and David Williams of R. R. Howell Company.

Do Water-Conditioning Gadgets Work?

Here are the answers based on the observations of engineers who have conducted rigorous plant tests

• *At the Fourteenth Annual Water Conference of the Engineers' Society of Western Pennsylvania, in October, 1953, the authors presented first-hand experience accumulated by their field engineers on "gadgets." Their paper subsequently was published in the May, 1954, issue of Industrial and Engineering Chemistry. Slightly condensed, it appears on the following pages.*

By B. Q. WELDER *and* EVERETT P. PARTRIDGE

Most human beings want to get something for nothing. Even the engineer with his basic belief that he can get out no more energy and matter from a system than the amount he puts in will hopefully buy a ticket that may give him a new auto if his number comes up. To this basic human trait, add the current belief that science can provide an easier way of meeting all our needs and you have an explanation for the many millions of dollars gambled annually on gadgets.

Let's define "water conditioning gadgets." By this term we mean devices which are supposed to treat water by non-chemical means and with practically no technical control. Usually they are claimed to have additional powers for good; for example, one or another will remove objectionable taste and odor from water, or remove slag deposits from the outside of tubes in a boiler, or improve the taste of a cigarette laid on the gadget.

Recently, the promotion of gadgets has been at one of its periodic peaks. They are supposed to put an end to troubles caused by deposition of scale or sludge, by corrosion and cracking, or by the accumulation of organic slimes — thus solving all problems. Thoughtful scientists and engineers naturally doubt the promoter's wild claims of universal utility. They suspect the pretended scientific jargon used to explain the electrical, catalytic, atomic or supersonic means by which a gadget is supposed to work. They recognize that warm testimonial letters are usually from persons who have not investigated the gadgets critically. As the result, the scientist or engineer often feels compelled to say, as some have done with courage and conviction, that these promotions are the bunk. Always, however, the practical man in the plant or in the water works wonders if the experts could be missing some new truth not yet fully understood.

In this article we take an objective look at what the gadgets themselves have accomplished when applied to specific water problems in specific plants. We present condensed case histories, each observed first-hand by one of the Hall Laboratories field engineers. The case histories end rather monotonously with the gadget tossed on the junk pile.

The various gadgets in the following case histories are classified according to two types — those involving an external electrical circuit and those not having such a circuit.

External Electrical Circuit

Gadget I-A. Gadget I-A consists of a cylindrical body in which is inserted a concentric slotted tube, both stated to be machined from castings of composition *M* naval bronze. The slotted tube is electrically insulated from the body. Water flows into the bottom of the body, from the annular space through the slots into the inner tube, and out of the top of the latter to use. The tube is the anode and the body the cathode of a cell through which a very small direct current is passed.

As stated in a descriptive brochure, the principle of Gadget I-A is as follows:

"The function of —— is to pass a small electrical current (in microamperes) through the water to influence the process of crystallization without making any detectable change in the chemical composition of the water. —— causes the dissolved hardness salts to crystallize in a different manner and the deposits are soft, thin, friable, and easy to remove."

Gadget I-A has been studied under controlled conditions in our own laboratory. Operation of an evaporator was simulated by using a coil of copper tubing, internally heated by steam at 10 pounds per square inch. The copper coil was immersed in the water to be evaporated, which was at atmospheric pressure. Feed water at room temperature was supplied automatically to replace that lost by evaporation and a blowdown of five per cent. All the water supplied to the simulated evaporator was passed through a commercial unit of the gadget supplied directly by one of the men at that time concerned with its promotion.

The effect of the gadget on scale formation was tested with two different types of water, Pittsburgh tap water, which deposits calcium sulfate scale, and a bicarbonate well water, which deposits calcium carbonate scale. In neither case did the passage of the feed water through the gadget show any improvement as compared to blank runs. There was no reduction in the amount of scale or the adherence of the scale to the copper surface. Neither the appearance of the scale nor the identity of the constituents was changed.

Gadget I-B. Gadget I-B is a plastic cylinder to be inserted in a water line. It contains electrodes said to be constructed of "special" materials, which are connected to a power line through a transformer in a control box. The principle is explained as follows:

"When water is passed through an electrical field of the proper intensity, the colloidal particles and dissolved salts act as a conducting medium. They pick up an electrical charge which is regulated in proportion to the conductivity of the water. These elements, which would ordinarily deposit on the walls and tubes of boilers and on the metal surfaces of other equipment, become repellent to these surfaces."

Installed on a line supplying a hard, bicarbonate well water to a hot water heater in an Indiana plant, the gadget failed to reduce the rate of deposition of calcium carbonate scale on the heater coils.

No External Electrical Circuit

An amazing variety of the more recent gadgets involve no external electrical circuit. It is as if the promoters had decided that the obviously electrical device had reached the end of its string, but that the expanding frontiers of science offered even more attractive bases for their sales stories.

Gadget II-C. Gadget II-C is a cylindrical tank similar to those for domestic hot water but equipped with a perforated tube or tubes running lengthwise, with caps at the ends projecting outside the tank. The unit is installed horizontally in the cold water line ahead of equipment or water systems to be pro-

Mr. Welder and Mr. Partridge, are engineers at, and the latter is director of, Hall Laboratories, Inc., Pittsburgh, Pa.

tected from scale and corrosion. Cylindrical cartridges with a brass case are slipped into the perforated tube from the outside before it is placed in use.

Promotion of this gadget in the United States apparently began early in 1950. Descriptive literature characterizes the process as catalytic, claims that it is a "revolutionary" French invention.

A novel feature of this gadget is the cycle of two days on and five days off specified for most efficient operation. For two days, referred to as the catalytic period, the unit is on the line with water flowing through it. Then for the following five days, called the inhibiting period, the water is by-passed around the unit. The drain cock and air vent of the gadget are left open during this period.

The cartridge, initially charged with negative electricity, is said to emit electrons through the water to a grounded metal surface.

"The electric field thus constituted in the interior of the mass of liquid augments the force of repulsion of the electrons around each atom, so that these electrons move farther away from one another, thereby modifying the architecture of the atom."

Apparently the Government was willing to allow publication of this disclosure while the Manhattan Project went on modifying the architecture of the atom the hard way.

Promotional material distributed to prospective users contains some additional charming bits of science fiction:

"When water normally used for industrial or potable purposes comes in contact with the —— catalytic cell, a para-ortho hydrogen conversion is created instantly. The ortho hydrogen acts on oxygen so that it becomes a very active element. Oxygen is a very strong paramagnetic gas. These two activated elements, the ortho hydrogen and the activated oxygen, then act on all the paramagnetic elements that exist in water. Most of the impurities in water are paramagnetic.

"All of the paramagnetic elements activated by the —— in water create an increase in the molecular magnetic field which disperses all of these activated elements and they remain dispersed after precipitation. This dispersion prevents the formation of the sticky hard scale in the water carriers. The precipitated elements, in the dispersed forms, then move easily with the natural flow in the carriers and all are eliminated by draining."

The following are considerations of practical performance.

1. A Texas utility had been feeding zeolite softened water to bent-tube evaporators and blowing down about six per cent. The gadget was installed on the basis that unsoftened bicarbonate water carrying about 1.5 epm of hardness (75 ppm as $CaCo_3$) could be used satisfactorily if the blowdown was increased appreciably. Within two weeks so much scale had formed that it was necessary to shut down the evaporator for mechanical cleaning.

2. In a Kansas utility plant, the surfaces of a heat exchanger were coated with a hard, dense calcium carbonate scale in only 19 days of operation after one of these devices was installed. The temperature of the exchanger influent water was 89° F., while the effluent was 105° F. It was soon found that the effluent temperature dropped and the cause was ascertained to be the build-up of $\frac{1}{8}$ inch of scale.

3. A plant in the vicinity of Washington, D. C., conducted a trial for a period of 15 weeks. The gadget was installed on the feed line to a 20-hp. vertical fire-tube boiler operating at 70 to 85 pounds per square inch gage on soft, untreated Washington city water. New tubes were installed just prior to the test, and inspection showed the shell at that time to be virtually free of scale. The boiler was operated continuously 24 hours per day except for three inspections during the 15-week period. At the end of this time, a considerable amount of scale was found on the tubes and tube sheet, and corrosion had taken place on the tubes at and above the normal water level. The results were judged by the operators to be equivalent to those obtained with no treatment. The plant was unable to contact the representatives who supplied the gadget.

4. An oil refinery in Texas installed the gadget on a pilot plant heat exchanger and cooling tower unit. Observation of the surfaces in the heat exchanger revealed no improvement, as compared to blank runs without the gadget.

5. A processor of oils and fats in Mexico found that use of this device resulted in serious scaling conditions and tube losses in a 150-pound-per-square-inch boiler producing 12,000 pounds of steam per hour.

6. A utility plant in Mexico applied the gadget to evaporator feed which constitutes the pretreatment to 675-pound-per-square-inch boilers. The process was discontinued after three months, since no noticeable improvement was experienced in the operation of the evaporators.

7. Results were unsatisfactory for a once-through cooling system using a high bicarbonate (400 ppm) shallow well water at 70° F. in a chemical plant in the South.

Gadget II-D. Gadget II-D is a heavily galvanized cast-iron fitting shaped like

■ *Sketch of a gadget, left, that has been exhibited at drillers' conventions in the past two or three years. At one of these meetings, the representative of the manufacturer said the "catalytic" influence of the device is so strong that if a bottle of Coca Cola were placed beside it when the gadget is working in a water system the Coca Cola syrup would separate and go to the bottom of the bottle, leaving the clear, carbonated water on top.*

This gadget, below left, is being promoted currently in many parts of the country and is said to "utilize a nuclear physics principle" for treating water.

At the Minnesota State Fair this year, a number of fake gadgets were exhibited. One was a round piece of concrete punctured with holes. If planted in a field, it was supposed to insure better crops; if sunk in a watering trough it was said to make cows give anti-biotic milk.

Among medical fakes, the most common is the electric belt, shown right, which is claimed to cure tumors, tuberculosis and diabetes by setting up a weak magnetic field around the wearer.

an oversized pipe coupling with an interior cross post. It is alleged that the unit

"is made entirely of specially processed cast metal which imparts catalytic action to water flowing through it."

The user is warned that, to get quick results,

"magnesium and zinc anode rods, bimetal devices, and other forms of cathodic equipment must be removed.

"On installations where the corrective action of —— Conditioning is not immediately noticeable on both the cold and hot water, *check the piping system thoroughly!* It will be found that there exists one or more electrically nonconductive joints of the types illustrated. When each such joint is properly shunted with bare copper wire the —— cannot fail to perform."

Although this gadget has only been called to the authors' attention during the past year, there are a number of case histories resulting from its particularly aggressive promotion.

1. A ceramics manufacturer in western Pennsylvania heats water from the Allegheny River to 200° F. in a heat exchanger. To see whether the gadget would reduce deposition, a comparison test was run with one exchanger operating directly on raw water and a companion exchanger supplied with water passed through the gadget. After a period of four months, the units were inspected. Both were found loaded with deposit to the same extent.

2. A textile plant in West Virginia, using water from the Ohio River, had accumulated scale in a compressor cooling system over a period of years. Promoters of the gadget claimed that it would clean up these lines; in fact, it was stated that scale would come loose in such large chunks that there would be danger of plugging the lines. The chief engineer, a most practical person, simply tied a pillowcase over the discharge line to catch the loosened scale. After 30 days of operation with the gadget in the line, the pillowcase was still conspicuously empty.

3. A dry-cleaning company in Philadelphia was told that installation of the gadget would improve the condition of the service line, improve the taste and odor of the water, and reduce scale in the evaporator making distilled water. No benefit in any of these respects was produced by the gadget.

4. A restaurant in Pennsylvania installed the gadget on the line to a tankless-type hot water heater. After 30 days of operation, the installation was widely publicized as a success by the promoters. After another three months in service, the heater was found to be almost completely plugged with scale.

5. A New England utility plant installed the gadget upstream from some new piping. After several months, this piping was found to be badly corroded. The piping was replaced and a second test was made, with the same results.

6. In a steel mill in the Midwest, cooling water saturated with oxygen enters gas coolers at about 80° F. and leaves at from 125° to 180° F. New test sections of the effluent line were corroded after exposure for 30 days to water passed through the gadget installed ahead of the gas cooler. The corroded appearance was the same as that observed without any treatment.

Gadget II-E. Gadget II-E is described as an

"inert metal electrode which when properly installed will, by electrical stabilization, convert usual adverse current to a vehicle promoting easier access of furnace heat to boiler water — this without changing your present method of boiler water treatment."

This gadget is said to cause the normal scale forming materials to precipitate as a sludge and be removed with the boiler blowdown.

1. A unit installed in a 90-pound-per-square-inch, three-drum, low-head boiler in a Missouri plant supplied with water carrying about 1.5 epm (75 ppm as $CaCO_3$) of hardness comprised heavy mesh screen welded on a number of lengths of 1-inch pipe and installed in the drum of the boiler. At the end of 60 days, the free trial was discontinued because formation of new scale was evident.

2. In a plant in Ohio, the steam drum was filled with frames of 1-inch stainless steel on which were mounted zinc screens. Two months later, the plant was shut down for a week by the failure of two tubes and the necessity of replacing 120 other tubes. Additional units of the gadget were installed in the water-wall headers. Inspection after one week of operation revealed that new scale was already forming on the 120 replacement tubes. Analysis showed this scale to be essentially calcium sulfate. Further replacements of tubes were necessary before the plant eventually adopted chemical treatment.

(To be completed in the next issue)

Water Producing Seen as New Industry

By ROBERT K. PLUMB

More than 1,000 towns and cities had to curtail water consumption last year because of shortages.

Present shortages combined with the possible increasing use of water suggests that a major new industry will develop — processing water from saline or brackish supplies.

This conclusion was reached at the recent national meeting of the American Chemical Society at the University of Minnesota, Minneapolis, Minn. Dr. E. R. Gilliland, professor of chemical engineering at the Massachusetts Institute of Technology, presented a report based on a new study of water usage.

Problem of Cost

Water can be supplied to any area, he added, but the problem is cost. In some agricultural and industrial areas, the cost is only one cent a thousand gallons. In other places it is $10 for the same quantity. Water delivered for household use averages about 30 cents a thousand gallons, Dr. Gilliland said, although some towns have to pay 50 cents.

At present farm prices, agricultural users probably cannot pay much more than they are now paying for water, he added, but in many industrial and municipal situations, higher prices would be justified.

The best method now for producing water is to take the minerals out of saline and brackish water. Several processes are known for demineralizing salt water, Dr. Gilliland said. The oldest is distillation. With modern refinements, he said, good water can be obtained by distillation in quantities of 5,000,000 gallons a day or more at prices ranging from 75 cents to $2 a thousand gallons. In smaller quantities, he continued, the price could be $3.

Process Uneconomical

The solar heating process for making water does not appear to be economical, he asserted. Similarly, attempts to utilize temperature differences between the oceanic surface and depths involve excessive costs, compared to prices of conventional fuels used in distillation, he continued.

Freezing should be a good way to obtain fresh water, he said. Potentially, he added, it should be one of the best methods, with costs on a large scale perhaps as low as 25 cents a thousand gallons. But major technological problems remain to be solved, he observed. Ice is nearly salt-free, he said, and melting would yield fresh water.

Solvent extraction of fresh water from a salt solution may cost more than $2 a thousand gallons, Dr. Gilliland noted. A system of reversed osmotic flow through semi-permeable membranes may be workable at a cost of more than $1.50 a thousand gallons, he added.

Ion-exchange columns, in which electrical effects are used to remove salt, have been employed effectively on

TOM'S COLUMN

(Continued from Page 7)

an old warehouse at th' far end of their building area. They had to get all th' work going at th' same time to get into production in time, an' what they wanted of us amounted to an answer to this one, simple question: "Can you get us a million gallons a day (700 gpm) of water and run a pumping main to connect to our new plant lines, and have it ready to go by three weeks from next Monday? If so, give us your price by tomorrow afternoon."

Well, we never felt better or worried less about going into a deal than into this one. We had all th' stuff that was needed, either on hand or under our fingers. By th' next Monday (three days later) we had th' deal closed, our location picked, and a rig set up. We had a ditcher an' a crew all set for running th' pipeline, too.

Convenient Spot Picked

Th' spot we picked for th' job was about half way between two test wells we had drilled th' first time we were there, years ago. This was th' most convenient spot for all purposes. One of the test wells had been about 100 feet north and the other about 100 feet southeast of this new location. There was another test well about 300 feet south of it. By Friday night we were through th' water-bearing sand and into th' clay at the bottom. Our pipeline was about half done. Everything moved along first-rate — except we were very surprised when we ran into th' clay at 96 feet. We rat-holed for about 15 feet to make sure this was th' bottom and we hit rock which proved it.

Another thing we noticed was that while th' sand and gravel was a nice size it was dirty. When we tried to check back on our old test well logs we couldn't find any mention about th' sand being dirty. It just said "coarse water-bearing sand and fine gravel." In them days we didn't do a very good job on our sample records. We've learned since then how important it is to give details.

Anyway, we ordered th' screen and put it in. A 16-inch, 10-foot screen with 50 and 60 slot openings. We developed it good for th' best part of a day and a half, then put in th' test pump. You could have knocked me over with a feather! 450 gpm pulled it down to th' top of th' screen.

Well, gentlemen, there was some soup simmerin' around Tom's place that night! We were all about as surprised as men could be — an' doggoned unhappy. I know these things can happen — an' they do happen every once in awhile, but I was so cocksure of this area being uniform that I went ahead without any hesitation. Then when we hit th' clay higher up than in the other wells, my experience should have made me suspicious. But it didn't.

Deadline Near

So what should we do next? We had a nice pipeline right up to th' well — but no well to hook up to it — and just 11 days including Sunday to get out of the mess.

Well, we did about all we could do. We put in a small test rig an' ran two test wells almost straight east of this well, over toward the old well No. 1, which was 113 feet to th' rock with no clay. In th' first of these test wells we ran into a mixture of clay and sand and gravel at 92 feet and didn't reach solid clay until 104 feet, an' then ran into th' rock at 108 feet. This was no good.

Th' second test well had cleaner sand and gravel right down to 98 feet then ran into dirty stuff, clay at 107 feet and th' rock at 111. This looked promising. By running a profile from th' test wells and th' main wells it looked pretty safe to locate another 100 feet east. We set th' main rig up an' ran down a quick test hole with th' test rig a few feet away an' found things o.k. We finished th' 16-inch well at 110 feet with a 15-foot screen, No. 80 slot, an' pumped 700 gpm with 17′ 6″ drawdown at the end of 10 hours pumping. We hooked to th' pipeline an' had water ready for them — with six hours of Saturday and all day Sunday to spare.

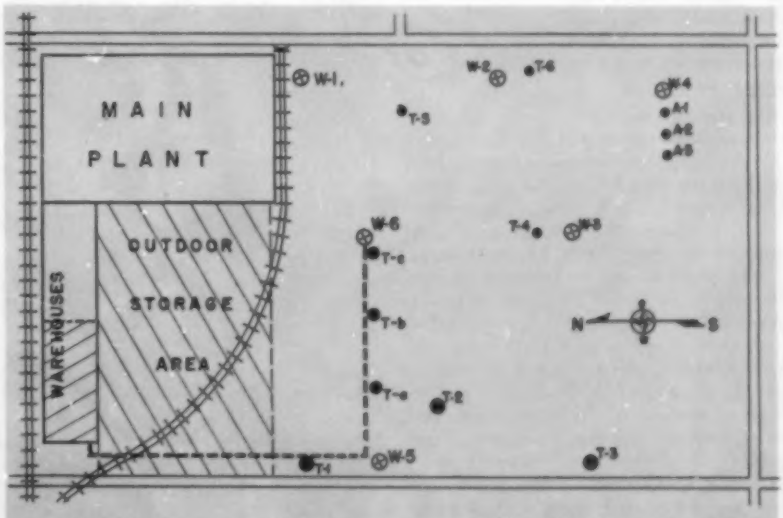
Close Call

That's what I call being saved by th' skin of your teeth. And they were all set to go Monday morning, too, so we would of looked pretty bad if we hadn't made it.

Now, you might say this wasn't my fault — but it really was. I shouldn't have been so cocksure of things. I should know by now that you can always be fooled by these formations and I should have run a test before I started on this kind of a job. What happened, of course, is that we got into a poor part of a good field and I paid to find it out to th' tune of several thousand dollars — which makes me think I'd better stop right here before I get to feeling too bad for myself!

Yer old friend,

Tom



Sketch showing property, test wells and pumped wells that Tom refers to. Test wells are T-1, T-2, etc. Test holes for last well are T-a, T-b and T-c. Pumped wells are marked W; abandoned well is W-5. Observation wells for drawdown readings are: A-1, A-2 and A-3.

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a small scale, he said, but costs range upward from $2 a thousand gallons.

New Systems Cited

According to Dr. Gilliland, newly developed electrical membrane systems for demineralizing water can treat sea water on a large scale at 60 cents a thousand gallons or more. Brackish water containing only 3,500 parts of mineral in a million parts of water can be treated electrically for only 15 cents a thousand gallons, he estimated.

He explained that the technical problems connected with fresh-water production by these methods had not been completely solved. When they are, he suggested, a new process industry will be established to supply fresh water for industry, agriculture and cities.

Permission to print this report of Dr. Gilliland's speech, which appeared originally in the *New York Times*, granted by that paper.

ASSOCIATION NEWS

This section is devoted to the exclusive use of water well drillers' associations, both state and local. Notices, announcements, changes of officers and other items should be sent to The Editor, Johnson National Drillers' Journal, 2304 Long Ave., St. Paul 14, Minnesota.

WISCONSIN

The Wisconsin Well Drillers, Inc., has announced that the 1956 convention of the organization will be held in Milwaukee on Monday, Tuesday and Wednesday, April 16, 17 and 18, 1956. The meetings and exhibits will be at the Hotel Schroeder.

The selection of the first three days of the week for the convention is a departure from the previous arrangements, but the committee believes there are a number of advantages to this schedule. Details of the program are being developed.

MISSISSIPPI

The original plans for a meeting of the Mississippi Water Well Contractors' Association in September had to be revised and the date of the meeting was moved up to October 14. The place is Memorial Park at Pass Christian. At this meeting new officers for the coming year will be elected and other important business of the association will be conducted. The program will also include a number of social events. Facilities for manufacturers' and jobbers' displays are available. Fred Sutter, secretary, is making all the arrangements.

C. O. Miller and Fred Sutter represented the Association at a meeting of the Water Resources Commission on September 8. Many interested industries were there to present their views and problems on water supply in this part of the state.

WASHINGTON

A regional meeting of the Washington State Well Drillers' Association was held in Ephrata on July 16. The work of the new Water Resources Policy Committee was discussed. This committee was formed to study water resources and water problems of Washington. It was decided to organize a committee of the Association to present well drillers' points of view to this agency in connection with ground water resources. Mr. W. E. Walcott of the Bureau of Reclamation gave an interesting and informative talk on the Columbia Basin area.

The next meeting of the association will be the annual two-day convention to be held at the Frye Hotel in Seattle on November 4 and 5. An excellent program will be presented and the annual business meeting of the association will be held. Every water well driller in Washington is urged to attend.

KANSAS

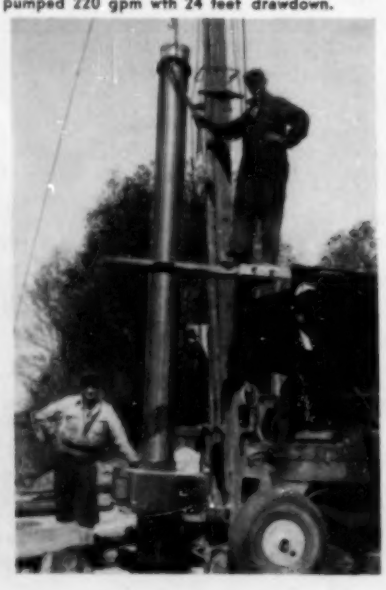
The annual meeting of the Kansas Water Well Drillers' Association will be held in Salina on October 21 and 22. The meetings will take place at the American Legion Home. In addition to a good program, there will be a number of exhibits of water well equipment and supplies. Final arrangements are being made by J. M. Jewett, service secretary, State Geological Survey at Lawrence.

Water-well drilling activities in Kansas have been at an all-time high this year. Public interest in ground water development has also been in evidence almost continuously. These two factors should result in unusually good attendance at the annual meeting of the association.

OKLAHOMA

The committee in charge of the arrangements predicts that the annual convention of the Oklahoma Water Well Drillers' Association will be the best ever this year. October 27 and 28 are the dates. Enid is the convention city. The Municipal Auditorium will house the indoor exhibits of equipment and materials. Drilling machines will be demonstrated in the outdoor exhibit space across the street. An excellent program has been arranged.

Twelve-inch Johnson Silicon Red Brass Screen, 12-feet long, being installed in well for Mountjoy Township in Ontario by E. O. Longstreet of Timmons. Completed well pumped 220 gpm wth 24 feet drawdown.



The Sooner Party will be just before the banquet on October 27. A complete ladies' program has been arranged under the direction of Mrs. Pearl Mayberry. It is hoped that every Oklahoma driller and his wife will attend this year's meeting. The two days will be filled with fun, fellowship, and educational interest.

TEXAS

The Texas Water Well Drilling Contractors' Association announces the starting of publication of its own magazine to be called the "Water Well Log." The first issue is to be mailed about October 15. The success of the exposition held last summer at Houston convinced the Association that the launching of this publication would be a worthwhile undertaking for the water well drillers of Texas and the surrounding states.

The "Water Well Log" is completely owned, edited and published by the Association. Mr. Tom Sneed has been selected as the editor and representative of the magazine.

OHIO

In the closing days of the last legislative session, the bill which was designed to set up a water well construction code and provide for registration of well drillers was defeated by a narrow margin. This action was a disappointment to the Ohio Water Well Drillers' Association which had sponsored the legislation. A minor technicality was responsible for the defeat. In spite of the failure to enact the law, it is apparent that a law of this kind is desired by many legislators.

A study of the existing law, under which the Water Resources Board operates, reveals that this board has authority to approve a code for water well construction and to set up certain penalties for failure to comply. The Association has requested the Water Resources Board to revise a previous draft of a proposed code and put it into effect as soon as the arrangements can be made. This matter was discussed in much detail at the August 20 meeting of the Association at Columbus and by the Board of Directors.

The annual business meeting of the Association will be held early in December in Columbus. Details will be mailed to all Ohio drillers soon by R. H. Stein, secretary.

COLORADO

This is the big convention year! Some three years have passed since an exposition of well equipment and supplies has been formally held in connection with a convention of the Colorado Wa-

ter Well Contractors' Association. So, both indoor and outdoor exhibit space has been arranged for manufacturers and suppliers who will be on hand to show the best and newest equipment on November 4 and 5 in Denver.

The annual convention will be held on these days at the Shirley-Savoy Hotel. Luther Symons has organized a fine program. The fun party and annual banquet will be held the evening of November 4. Every effort has been made to insure a profitable and interesting meeting. A record attendance is expected.

The Association is continuously active in the interests of Colorado water-well drillers. It is helping to establish better relations in the drilling business and a solid foundation for continued progress that will benefit every driller in the state.

NWWA Exposition

Long Beach, California, in the land of sunshine has been selected as the site for the 1955 National Water Well Exposition. For the benefit of those water-well contractors and wives who live in the East and Middlewest, a special train is to leave from Chicago on Thursday, November 10. The route will be through Cheyenne, Salt Lake City, with a stopover at Las Vegas, Nevada, then on into Los Angeles on Sunday, November 13. For further information on this, contact the NWWA office at Urbana, Illinois.

The exposition of water-well equipment, pumps and selected supplies will be the best ever. An excellent program has been planned. As a special event for ladies, a luncheon with fine entertainment will be given by the Manufacturers' and Suppliers' Division. In addition many pre- and post-convention activities have been set up to make the trip to Long Beach both educational and entertaining.

According to President Wright, one of the highlights of the convention will be a motor caravan into Mexico, to Tijuana (Tia Juana) and Rosa Rita Beach. This event will take place on Saturday following the Exposition. Mr. Wright promises an unusual and interesting excursion with plenty of opportunity to buy authentic Mexican products.

The dates again — November 15 to 19. Go if you can. You'll have a wonderful time!

Virginia

The annual meeting of the Virginia Water Well Drillers' Association was held in Richmond on September 21. Three new directors were elected to serve for three years. James G. West, Jr., was elected president for the coming year.

The main topic of discussion at the meeting centered around possible legislation relating to the control of ground water development. The majority of the members feel that legislation in this field should be the last resort. It is believed that more satisfactory results can be obtained through education of both drillers and the general public, and through publicity to explain the economic effects of improper development or pollution of ground water supplies.

The Association will have a spring meeting, which has been scheduled for May 25 and 26, 1956.

Canada Reduces Duty

Canadian import duties on well screens manufactured in the United States were reduced in August from 22½ per cent to 10 per cent of invoice value. Well points have long been imported under a duty of 10 per cent. Tariff Item 422 A has now been revised to include both well points and well screens at the 10 per cent rate.

The Ontario Water Well Association was influential in supporting the application for this change. The work of the Association was much appreciated by U. S. manufacturers. It is expected that the new duty rate will be maintained until such time as well-screen manufacture may develop in Canada as a home industry.

"Yeah, it's a pretty good card for a change. If you want a thing done right, do it yourself, I always say."

The flood disaster in Connecticut in August wrecked plants of the American Brass Company in Waterbury, Torrington and Ansonia. Everdur and silicon red brass used in making Johnson Well Screens comes from these plants. This view shows the havoc inside one of the buildings at Torrington just before starting the mean, dirty and exhausting jobs of clean-up and repair.

ADVERTISEMENTS

We will insert advertisements for drilling equipment wanted or for sale, help or work wanted, etc., for our readers, free of charge. Advertisements must be brief, and we cannot assume responsibility for them, but will be glad to put parties in touch with each other by this means and suggest that they investigate any offers or inquiries carefully for themselves.

FOR SALE: Bucyrus-Erie 21-W drill, 1947 model, mounted on 1½ ton 1941 Dodge truck. Has cathead, 500 feet ⅝" drill line, 350 feet ⅜" sand line. Price $2,250. John R. Johnson, Cokato, Minnesota.

FOR SALE: Well machine like Howell No. 60, hand-wheel type, trailer mounted; all steel construction. Charles Minett, Russell, Minnesota.

FOR SALE: Bucyrus-Erie 21-W drilling machine with Allis-Chalmers power unit, mounted on 1½-ton 1946 GMC truck. Has one cathead, and 500' each, ⅝" cable and ⅜" sand line. Clarence Heil, Brownton, Minnesota.

FOR SALE: Model 21-W drill mounted on 1½ ton 1946 Chevrolet truck. Has over 500' of ⅝" cable and equipped with catheads. E. W. Geib Well Company, Arlington, Minnesota.

FOR SALE: No. 240 Speed Star, 1947 model, mounted on 1½-ton truck; with cables and string of 4" tools. Price $1,500. Jerome Primus, 1023 14th Ave. SE, St. Cloud, Minnesota.

WANTED: Used, truck-mounted, cable-tool drill with steel frame. Prefer shock absorber and winches for pulling pipe. Need 4" to 6" capacity with or without tools and lines. Mr. M. D. Love, Emerald, Wisconsin.

FOR SALE: No. 42 Cyclone drill, all steel, mounted on 1946 Studebaker; tools and 600 lines; $3,700. All steel machine on 1946 Studebaker with 6" tools and lines, $1,200. Failing 1500 rotary on 1954 International 170; tools and drill pipe, $17,500. Caterpillar motor patrol, $500. Four-inch centrifugal pump, $200. Circle jack, $65. Herschel Mourning, Colchester, Illinois.

POSITION WANTED: Married, Dutch, 29 years old, experienced cable-tool water well driller, Ruston-Bucyrus 22-W outfits. Sober, careful and able to drill without supervision. Want permanent job any place, but subtropical and tropical countries preferred. Worked Indonesia (the former Dutch East Indies) and Africa. At present in Holland. Harry A. van Aken c/o Edward E. Johnson, Inc., 2304 Long Avenue, St. Paul 14, Minnesota.

FOR SALE: Model L, Fort Worth spudder, practically new; mounted on semi-trailer; Waukesha engine; tools for 5" and 6" holes. Includes 500' each of ⅝" and ¾" lines. 1947 Chevrolet tractor. New 350 gal. water tank; 1946 Ford flat-bed truck; other miscellaneous items. Price $4,500. J. R. Farmer, 2214 Loving Road, Graham, Texas.

WANTED: Man experienced with deep-well turbines and water systems needed by long-established company in southeastern Michigan. Give age, experience and qualifications. Excellent salary for right man. Box MIC, c/o Edward E. Johnson, Inc., 2304 Long Avenue, St. Paul 14, Minnesota.

FOR SALE: Model 35 Armstrong drilling machine, trailer mounted (6.00x20 Budd wheels) with 1941 Ford flat-bed truck. Includes ⅝" cable and 2x3-7 API tool joints. Price $1,975. Oasis Drilling Contractors, 225 W. Main, Waukesha, Wisconsin. Phone: Liberty 7-3514.

DRILLER WANTED: Cable-tool or rotary operator to drill water wells on commission. Herschel Mourning, Colchester, Illinois.

FOR SALE: Model 21-W Bucyrus-Erie drill on Ford truck. O. E. Lewis, Darlington, Indiana.

FOR SALE: Cyclone 35 drill, 1954 model, truck mounted. String of 4" tools, 250' drilling and sand lines, hand tools. Reasonable price. Everett Justin, Box 86, Boody, Illinois. Phone Elwin 2115.

FOR SALE: 21-W Bucyrus-Erie drill, 1946 model, mounted on 1941 International truck. Catheads, 500' of new ⅝" cable, 500' of ⅜" cable. Price $2,000 cash. Austin Wittlief, R.F.D. Two Harbors, Minnesota.

FOR SALE: Winter-Weiss, reverse-circulation drilling machine, 1954 model, on semi-trailer with 1954 Ford F-600 tractor. Complete with drill bits, 150' of drill stem and spare parts. Excellent condition — ready to drill. Write Box V D C c/o Edward E. Johnson, Inc., 2304 Long Avenue, St. Paul 14, Minnesota.

WANTED: Sales engineer or geologist, with experience in well drilling and turbine pumps, to design and sell wells for municipalities and industry. Salary and profit-sharing. Give all experience and references in first letter. Keys Well Drilling Co., 413 North Lexington Avenue, St. Paul 4, Minnesota.

FOR SALE: Bucyrus-Erie 20-W drill that has drilled only two wells. Has calf reel and spooling device; with or without truck. Also, B-E 22 drill with spooling device, casing reel, power derrick-hoist. Mounted on Reo truck; good condition. Priced to sell. H. A. Butler, P. O. Box 96, Delafield, Wisconsin.

FOR SALE: All-steel jet drilling machine with drill line, tools and equipment. 1947 Ford truck with water tank; 1950 Fork pick-up. New 300-gal. gas tank; some pipe and pipe racks; 12' x 12' shed, nearly new; two lots in Hecla. John Lahman, Hecla, South Dakota.

DRILLER WANTED: Drill operator for Bucyrus drill, mostly 6-inch wells. Must have experience on sand and gravel wells. Steady work, with wage and bonus on footage. H. A. Butler, P. O. Box 96, Delafield, Wisconsin. Phone 33.

FOR SALE: Sullivan rotary, 3,000' capacity, 5 x 8 pump, Diesel power. Winter-Weiss rotary with long mast and long kelly and with compressor. Also, Mayhew 1000 and Failing 1000. Fred E. Butler, Box 481, Pueblo, Colorado.

FOR SALE: Keystone drill with steel frame, self-propelled; Waukesha engine. Cheap. H. A. Butler, P. O. Box 96, Delafield, Wisconsin.

FOR SALE: Armstrong drill, semi-trailer mounted, with 1½ ton Chevrolet truck; 500' of ¾" cable, 500' of ⅜" sand line, large cathead, and power hoist for mast; complete string of 5" tools. Has Allis-Chalmers W C engine, recently overhauled; self-starter. Lindsay Bros., 400 North 1st Street, Minneapolis, Minnesota.

FOR SALE: Drilling business; including 20-W Bucyrus-Erie drill, mounted, with 4 sets of cable tools. Also tools for 2" and 3" well repair work. Want to retire. Good location. Leonard J. Weber, Fowler, Michigan.

FOR SALE: Failing rotary drill mounted on 1951 Fork truck; complete with drill pipe and tools. Water truck, 1952 Ford with Guffin tank, front-end winch, 2-speed axle, mud tires. A-1 condition. Bargain for water-well, test-hole, shot-hole or core drilling at $5,500. H. V. Hueppelsheuser, 822 East Maple, Enid, Oklahoma. Phone AD 7-2690.

DRILLER WANTED: Cable tool driller, also power auger operator, to work on commission or footage. Give age, experience and qualification in letter. Spitzer Well Co., Tracy, Minnesota.

FOR SALE: Two No. 42 cyclone drills, one 1952 model on 1952 Chevrolet truck, driven only 4,000 miles, and one 1954 model on 1947 Chevrolet truck with new motor. Both machines complete with cable and tools. Good condition. Lee L. Cummings, Route 1, Seymour, Indiana. Phone 3028 W.

FOR SALE: One shop-built rotary drill, all-steel, trailer-mount, 32-ft. mast, 22-ft. kelly bar, 2⅝" drill pipe, good tool joints. Machine well-equipped with bits from 5" to 30". All sizes of bailers, new mud pump and new water tank. Rig now operating. Due to ill health will sacrifice for immediate sale. S. J. Catlett, 2408 Main, Woodland, Oklahoma. Phone 797 J.

FOR SALE: New 55 Speed Star mounted on 1½ ton 1951 Dodge truck. All in perfect condition. L. J. Kessler, Troy, Missouri. Phone 349 J.

FOR SALE: Ferguson drilling machine, truck-mounted with cable; John Deere motor. Fair condition. Price $400. Ervin Halverson, Rake, Iowa.

FOR SALE: No. 33 Armstrong drilling machine with Allis-Chalmers motor; 600' of ¾" drill line and 600' of ⅜" sand line. Mounted on 1945 Ford cab-over-engine truck with new motor. All in good condition. Price $2,000. Nelson Brothers, Decorah, Iowa.

FOR SALE: Side-opening swivel socket; set of 4¼" drilling jars; 4" x 13' drill stem; combination socket for 5" hole and for 8" hole; all tools have 2 x 3 API joints. Also offer a late model drilling machine that swings 2,500 pounds of tools. Mitchhart Brothers, Sycamore, Ohio.

WANT TO BUY: Drilling machine that will drill from 1,000 to 1,600 feet deep and

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FACTORS AFFECTING WELL YIELD

(Continued from Page 5)

4. Screen slot openings should be V-shaped and widen inwardly so that they are non-clogging.

5. The screen should be made of corrosion-resistant material that will not be attacked by corrosive ground water nor by acid, should acid treatment of the well become necessary.

6. The screen must be strong enough to resist both the lateral earth pressure in the well and all other forces to which it will be subjected during installation.

Conclusions

The potential capacity of a water-bearing sand or sand-gravel formation to yield water is governed primarily by the permeability, extent and thickness of the formation. Development of the full yielding capacity of the aquifer by the construction of screened wells depends on the depth of penetration, screen design, drawdown, method of development and to a limited extent on well diameter. There are other technical details of ground water hydraulics and hydrology that might be discussed. However, the presentation of the fundamental principles in this article will serve as a reliable guide for choosing the various elements of the well structure to get the desired end results — maximum yield and efficient operation.

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possibly second machine for 600 to 1,000-ft. holes. Give complete description in letter, list of tools, where located and the price. Herbert Morrison, Vinton, Ohio.

FOR SALE: New Bucyrus-Erie tools, never used. Two 8" bits, $125; drill jars, 4¾", 7" stroke, $195; wire-rope, swivel sock with Mandrel, $67; 4" x 12' drill stem, $115; all with 2¼ x 3¼ joints. Also set of 3½" claw-end tool wrenches. C. K. Schmudlach, Fredricksburg, Iowa.

DRILLERS WANTED: Two good drillers for work vicinity of Stillwater. Mantyla Well Company, Stillwater, Minnesota. Phone Cottage Grove 2311.

FOR SALE: Bucyrus-Erie 21-W drill, truck-mounted; in working order, ready to go; 2 x 3-7 API tool joints. Price $3,500. Oasis Drilling Contractors, Waukesha, Wisconsin. Phone Liberty 7-3514.

FOR SALE: No. 45 Armstrong, all-steel drill; 39' mast with B-E top; power hoist; with cables; with or without tools; Le Roi engine. Good condition. Also 1952 model No. 42 cyclone drill on 2-ton 1945 Dodge truck with new tires and motor. Machine has 36' mast, power hoist, nearly-new sand and drill lines; with or without 4" to 10" tools. Selling because need larger equipment. L. J. Watson, 155th & Western Avenue, Route 1, Harvey, Illinois. Phone 951-R.

FOR SALE: Established well business, including Howell No. 60 drilling machine, repair rig, small inventory; home and 6 lots. Reasonably priced. Loren Blume, Box 101, Belle Plaine, Minnesota. Phone 269.

FOR SALE: Deep-well, turbine pumps, reconditioned and guaranteed; in stock. Capacities 100 to 1,500 gpm; 80' to 400' TDH; 10 to 40 HP. Reasonably priced. Geo. L. Smith, 6450 W. River Parkway, Milwaukee 13, Wisconsin.

FOR SALE: Failing 750 drill, auto chuck, power breakout table, 4½ x 5 duplex pump, 28' mast. Has 300' of 2⅞" drill pipe. Elmer Crain, Boyne City, Michigan.

WANT TO BUY: Good used drilling machine with or without tools. William O. Stout, Route 1, Xenia, Ohio.

DRILLERS WANTED: Cable-tool and rotary for water wells in Turkey; with satisfactory qualifications and experience to complete jobs without supervision. Send application giving brief data on identity, biography, experience, credentials and recent picture. Ilbank-Temel Ltd., P. O. Box 318, Galata, Istanbul, Turkey.

WANT TO BUY: Bucyrus-Erie 22 W, truck mounted, with or without tools. Bihn's Well Drilling, Walbridge, Ohio. Phone Toledo, Lenox 6949, after 6 P.M.

WANT TO BUY: Two Failing 1500-S drilling machines, skid-mounted; complete with tools for 700-foot holes 8" to 18" diameter. Other similar machines will be considered. Also, spare 6 x 6 mud pump. Box E A G c/o Edward E. Johnson, Inc., 315 North Pierce Street, St. Paul 4, Minnesota.

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